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METHOD AND DEVICE FOR FORMING A PIPE

BACKGROUND OF THE INVENTION

【0001】 This invention relates to a method and a device for forming a pipe in which a plate with holes is formed into a completely circular pipe by ~~means~~ use of a bending machine.

【0002】 A method of forming a completely circular pipe by bending a steel plate by use of a bending machine has heretofore been ~~carried out~~ performed with a bending machine in which one upper roll is vertically and horizontally movably arranged over two lower rolls arranged parallel to one another. ~~The~~ A pipe forming method disclosed in JP patent publication 63-36852 is one example. This prior method comprises a preparatory step of bending a central portion, a main step and a step of bending both ends of a plate.

【0003】 In the preparatory step of bending the central portion of the plate, the upper roll is lowered offset relative to the two lower rolls to a position where frictional force necessary for ~~the~~ feed of the plate ~~work~~ is obtained. Thereafter, the upper roll is further lowered while pressing and bending the plate ~~work~~ for rolling the plate until a predetermined arc necessary for the main step is obtained. After ~~carrying out~~performing the main step in which rolling is further ~~carried out~~performed with the predetermined arc, the both end bending step is ~~carried out~~performed in which pressing/bending is applied to both ends of the ~~work~~ plate.

【0004】 With this bending method, it is possible to bend a steel plate into a U-shape using part of its working steps. One example of such a method is proposed in JP patent publication 2000-288635. In this U-bending method, after moving a

steel plate clamped between ~~the~~ an upper roll and ~~the~~ two lower rolls to a predetermined forming start position, the upper roll is lowered with a lowering amount divided into a plurality of portions so as to form a predetermined arc, while rotating the lower rolls in normal and reverse directions at rotating amounts corresponding to ~~the~~ lowering amounts to ~~carry out~~perform multiple step ~~forming~~ formation while gradually narrowing each ~~forming~~ formation toward ~~the~~ a minimum curvature portion.

【0005】 ~~The bending~~Bending methods by use of the bending machines described in these two patent publications are used for flat plates in which no holes are formed. No mention is made about what influence ~~the fact that~~ holes ~~are~~ being formed in a flat plate will have on ~~the~~ work accuracy ~~if a hole is formed in~~when forming the flat plate into a pipe. If a pipe is actually formed by applying the bending method of JP patent publication 63-36852 to a work with holes, it is known from experience that no normal bending is possible near ~~the~~ portions where ~~there are~~ the holes are present, and ~~the~~ a radius of curvature partially decreases at such portions and the pipe is not made to be completely circular.

【0006】 Thus, in forming a pipe with holes, in order to obtain a completely circular pipe, ~~it~~ a plate has to be treated by one of the following two methods. That is, the pipe forming method of JP patent publication 63-36852 is applied without forming any hole in the plate ~~work~~ to form a completely circular pipe, and thereafter, holes are formed at predetermined positions by use of a drill. Otherwise, after a pipe has been formed by applying this pipe forming method to one in which holes have been formed in ~~the~~ a work beforehand, bending is ~~carried out~~ performed again with a different kind of press ~~means~~ device to correct ~~the~~

curvature of the pipe, which is out of true at ~~the~~ hole portions.

【0007】 But, simply by applying the pipe forming method of JP patent publication 63-36852, it is impossible to obtain a completely circular pipe. If holes are formed with a drill after forming a completely circular pipe, the pipe may become partially not completely circular due to ~~the~~ influence of drilling. If a material formed with holes is formed into a pipe, it may develop portions which are partially not completely circular. Thus, it is necessary to ~~carry out~~perform bending again at such portions. Thus, extremely complicated steps are needed. So it is difficult to obtain a completely circular pipe with a bending machine alone. A different kind of machine and step are needed for correction.

【0008】 An object of this invention is to provide a method and a device for accurately and efficiently forming a pipe with a bending machine only, without using ~~correcting means~~correctional measures, by ~~in~~ uniformly bending a plate ~~work~~ with holes to a pipe diameter.

SUMMARY OF THE INVENTION

【0009】 According to this invention, there is provided a method of forming a pipe comprising ~~the~~ steps of: feeding a plate ~~work~~ having a hole between an upper roll and a pair of lower rolls of a bending machine, the lower rolls being parallel to each other and relative to the upper roll~~,~~; moving the plate ~~work~~ by ~~the~~ rotation of the lower rolls while supporting it with the upper and lower rolls~~,~~; and forming a pipe by bending the plate ~~work~~ under pressure of the upper and lower rolls, wherein ~~the~~ this forming comprises a rough forming step in which the plate ~~work~~ is formed into a pipe having a rough radius, and a fine forming step ~~followed~~

~~by~~following the rough forming step for finishing the pipe to a required radius~~, wherein in~~. In the rough forming step, the plate ~~work~~ is bent by pressing it with the upper and lower rolls so that a required radius will be obtained at a hole portion, and in the fine forming step, no bending action is applied to the hole portion and the plate ~~work~~ is rolled by pressing it with the upper and lower rolls so that at a portion other than the hole portion, ~~the~~ a radius will coincide with that at the hole portion.

【0010】 According to this invention, there is also provided a device for forming a pipe comprising an upper roll and a pair of lower rolls which are parallel to each other and are arranged so as to vertically oppose each other~~, one~~. One of the upper and lower rolls ~~being~~ is provided so as to be movable vertically and horizontally relative to the ~~other, actuators~~ others. Actuators are provided for rotating, raising and lowering the rolls so as to move the rolls while supporting a plate ~~work~~ with holes which is supplied between the upper and lower rolls by ~~the~~ rotation of the rolls, and simultaneously bend ~~it~~ the plate under ~~the~~ pressure of the rolls to form a pipe~~,~~. Also provided is a control unit for controlling the actuators, the control including a control program for controlling a pipe forming step comprising a rough forming step in which the plate ~~work~~ is formed into a rough radius, and a fine forming step ~~followed by~~following the rough forming step for finishing ~~it~~ the plate to a required radius~~, wherein in~~. In the rough forming step, the plate ~~work~~ is bent by pressing it with the upper and lower rolls so that a required diameter will be obtained at ~~the~~ hole portions, and in the fine forming step, no bending action is applied to the hole ~~portion~~ portions, and the plate ~~work~~ is rolled by pressing it with the upper and lower rolls so that at portions other than

the hole portions, the pipe radius coincides with that of the hole portions.

【0011】 With ~~the~~ this method and device for forming a pipe, simply by operating a bending machine, without using any other auxiliary ~~means~~ measures or without needing troublesome auxiliary work, a finished product of a pipe can be formed by bending. In a method in which a pipe is formed by bending a plate ~~work~~ having holes, influences of pressing are different between ~~the~~ hole portions and other portions. Thus, in ~~the~~ a rough forming step, bending is ~~carried out~~ performed such that ~~the~~ a radius near the hole portions will be a required radius, which is ~~the~~ a radius of ~~the~~ a pipe of the finished product. ~~The~~ A radius of ~~the~~ portions other than the hole portions is slightly larger than the required radius.

【0012】 Thus, in ~~the~~ a fine forming step, rolling is ~~carried out~~performed on portions other than the hole portions to apply bending so that ~~the~~ a required diameter is obtained. Since the hole portions are already worked to a required radius, by feeding the plate ~~work~~ with the upper roll separated from the ~~work~~ plate, or supporting it with the upper and lower rolls so that a bending action is not applied, and thereafter by lowering the upper roller and continuing rolling, ~~the~~ a radius of the portions other than the hole portions approaches the required radius, so that a pipe of a finished product is obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

【0013】 Other features and objects of the present invention will become apparent from the following description made with reference to the accompanying drawings, in which:

Fig. 1 is a block diagram of a control line with a perspective view of ~~the~~

a bending machine embodying the present invention;

~~Fig. 2A is a view~~ Figs. 2A(a)-2A(f) are views for explaining ~~the~~ a rough pipe forming step;

~~Fig. 2B is a view~~ Figs. 2B(g)-2B(l) are views for explaining ~~the~~ a fine pipe forming step;

Figs. 3A, 3B and 3C are flowcharts of the rough pipe forming step;

Figs. 3D and 3E are flowcharts of the fine pipe forming step;

~~Fig. 4 is an~~ Figs. 4A-4C are explanatory ~~view~~ views of the fine pipe forming step; and

Fig. 5 is a view showing holes of a ~~work~~ plate.

DETAILED DESCRIPTION OF THE PREFERRED ~~EMBODIMENT~~ EMBODIMENTS

【0014】 ~~The~~ An embodiment of this invention will be described with reference to the drawings. Fig. 1 shows a perspective view of ~~the~~ a bending machine of an embodiment with a block diagram of a control circuit for controlling driving units (or actuators). This bending machine has an upper roll 1 arranged between opposed frames F, and two lower rolls 2 and 2' provided below the upper roll 1 so as to be parallel to each other and relative to the upper roll 1. The upper roll 1 is provided so as to be moved up and down by a hydraulic cylinder 13 and to be movable back and forth by a motor 10.

【0015】 The lower rolls 2 and 2' are rotated in normal and reverse directions by a motor 6. While backup rolls and 2' are provided below the lower rolls 2, they are omitted for simplicity. A hydraulic cylinder 12 is provided to outwardly

incline each frame F. In this embodiment, as the actuators, the motors 6, 10 and the hydraulic cylinders 12, 13 are provided.

【0016】 ~~The operation~~Operation of the bending machine is controlled by a control circuit 5. ~~It~~ The control circuit comprises a sequencer for ~~carrying out~~performing control based on signals from a numerical setter 5s. A numerical setter 5a is for setting rotating amounts Z (Z1, Z2, ...) of the lower rolls 2, 2', which are converted to moving amounts of a plate ~~work~~ W. A numerical setter 5b is for setting vertical movement amounts Y (Y1, Y2, ...) of the upper roll 1, and a numerical setter 5c is for setting horizontal movement amount X of the upper roll 1.

【0017】 For these set values Z, Y and X, values set at the numerical setters 5a-5c based on bending parameters such as ~~the~~ a yield point of ~~the~~ material, plate thickness, plate width, radius of curvature R and ~~the~~ a size and position of ~~the~~ holes are input into the control circuit 5 beforehand. ~~The numbers~~Numbers of revolutions of the lower rollers 2 and 2' are detected by signals from rotation sensors 7 and are converted to distance L in the control circuit 5.

【0018】 Vertical movement of the upper roll 1 is ~~carried out~~performed by feeding hydraulic pressure to the hydraulic cylinder 13 by a hydraulic pressure control circuit 8. ~~The amounts~~Amounts of its vertical movement are detected by a position detector 9 mounted on a side frame F. ~~The horizontal~~Horizontal movement of the upper roll 1 is detected by a position detector 11 mounted on a lower frame. Operations of the motors 6 and 10, and the hydraulic cylinders 13 and 12, are controlled based on commands from the control circuit 5. Detected values of the position detectors 9 and 11, and the rotation sensors 7 are input to the control circuit 5.

【0019】 ~~The~~ A method of forming a pipe by bending a plate by ~~means of~~ using this bending machine will be described below with reference to Figs. 2A and 2B and the flowcharts of Figs. 3A-3E. When a start button of the bending machine is pressed, the control circuit will begin control based on signals from an input device, selected beforehand from among control modes by an operator. In this control action, ~~the operation~~operational conditions at ~~the~~ a start are checked, and if there should be any abnormality, "abnormal message" is displayed.

【0020】 If there is no abnormality, it is determined that preparation for working has been completed, and ~~the~~ actions shown in Fig. 2A and ~~the~~ subsequent figures will begin. First in step S1 of Fig. 3A, ~~the~~ backup rolls (not shown) are moved up or down, and in step S2 it is judged whether the backup rolls are at predetermined position H1. After a stopper 3 for the plate ~~work~~ W (steel plate) has been raised in step S3, as shown in Fig. 2A(a), the plate ~~work~~ W is fed from ~~the~~ rear lower roll 2' toward ~~the~~ front lower roll 2 ~~into~~ between the upper roll 1 and the lower rolls 2, 2', and the plate ~~work~~ W is held with its front end abutting the stopper 3, which is arranged so as to be parallel to the lower rolls 2 and 2'. Also, before the start of operation, the upper roll 1 is at a standby position Y0 which is above the lower rolls 2, 2'.

【0021】 In response to ~~the~~ a plate ~~work~~ feed end signal, the upper roll 1 is lowered to position YL (not shown) in step S5. In step S7, the upper roll 1 is moved from standby position X0 to position X1 toward the rear lower roll 2'. In step S9, the upper roll 1 is lowered to set position Y1 to clamp the plate ~~work~~ W (see Fig. 2A(b)). In step S11, the lower rolls 2, 2' are driven to move the plate ~~work~~ W so that the front end of the plate ~~work~~ W will come to a position right over

the front lower roll 2 and spaced a distance Z1 from the stopper 3 (Fig. 2A(b)). ~~The values~~Values X1, YL, Y1, Z1 are values calculated according to ~~the~~ a bending mode beforehand and stored in the control circuit 5. The ~~step~~ process automatically proceeds to ~~the~~ a next operation after the plate ~~work~~ arrives at the set position.

【0022】 ~~The below-described~~Below-described Y2, Y3 ..., Z2, Z3 ... etc. are also values calculated and set according to the bending mode. In the state of Fig. 2A(b), the upper roll 1 is still set at position Y1 where the plate ~~work~~ W is retained in a horizontal state. In this position, no bending action is ~~given to~~performed on the plate ~~work~~ W. This completes ~~the~~ setting of the plate ~~work~~ W to ~~the~~ a forming start position. After lowering the stopper 3 in step S13, the lower rolls 2, 2' are driven in step S14 to move the plate ~~work~~ W forward to start forming the plate and to feed ~~it~~ the plate to set position Z2. Simultaneously with ~~the~~ start of ~~forming~~ this formation, as shown in Fig. 2A(c), in step S16, the upper roll 1 is lowered to set position Y2-θ. The plate ~~work~~ is subjected to bending under ~~the~~ a pressing force applied by the upper roll.

【0023】 Driving of the lower rolls 2, 2' and lowering of the upper roll 1 are started substantially simultaneously. Y2 is a value necessary for keeping the upper roll 1 at a set position as shown in Fig. 2A(f). In the state of Fig. 2A(c), the upper roll 1 is set at set position Y2-θ which is just before the set position Y2.

【0024】 While the plate ~~work~~ W is being fed to set position Z2 in step S15, it takes time for the upper roll 1 to lower to set position Y2-θ. Bending during this time is in a spiral form because ~~the~~ a position of the upper roll 1 changes little by little. By further bending the plate W after the upper roll 1 has lowered to set

position Y2-θ, an R' portion is formed with ~~the~~ radius R'. But a portion of a predetermined short length from the front end of the plate ~~work~~ W is left unworked. Thus, in step S18, as shown in Fig. 2A(d), the upper roll 1 is lowered to set position Y3 (in step S19) to ~~carry out~~perform press end bending. Bending up to the length Z2 thus ends.

【0025】 Next, ~~the~~ an entire circumferential length of the plate ~~work~~ W is formed into a pipe of a desired radius R (R>R') by reversing ~~the~~ a feed direction of the plate ~~work~~ W as shown in Fig. 2A(e). First, from the state of Fig. 2A(d), in step S22, while raising the upper roll 1 to set position Y2-α, the lower rolls 2, 2' are driven in step S20 in ~~the~~ a direction opposite ~~direction~~ to set position γ. This is done to stabilize the plate ~~work~~ W on the lower rolls 2, 2' while the upper roll 1 is being moved to set position X2 in ~~the~~ below-described step S24.

【0026】 After raising the upper roll 1 to set position Y2-α, in step S24 shown in Fig. 3C, the upper roll 1 is moved in ~~the~~ an opposite direction to set it in set position X2 as shown in Fig. 2A(e). After setting the upper roll 1 in the above position, the upper roll 1 is lowered in step S26 to set position Y2, and the lower rolls 2, 2' are again driven in step S28 in the opposite direction to feed the plate ~~it~~ to set position Z3 (in step S29).

【0027】 When the radius R' portion, spiral portion and straight portion pass, bending to a desired radius R is ~~done~~ performed by the upper roll 1 which is set at position Y2, and the lower rolls 2, 2'. Further, in the same manner as in step S18, press end bending is ~~done~~ performed for a portion of a predetermined short length from ~~the~~ an opposite end by lowering the upper roll 1 to set position Y3 in step S30. Thus, as shown in Fig. 2B(g), a pipe of ~~the~~ desired radius R is formed over ~~the~~ an

entire circumference of the ~~work~~ plate.

【0028】 This is a rough forming step ~~carried out~~performed by bending the plate ~~work~~ W. This bending of the plate ~~work~~ W is working to a desired radius R. The radius R is slightly larger than ~~the~~ radius R0 of a pipe as ~~the~~ a finished product to be ultimately obtained (R0<R). ~~The~~ A reason for this is that as shown in ~~Fig.~~ 4Figs. 4A-4C, at portions near holes h of the plate ~~work~~ W, ~~the~~ influence of bending is stronger than at portions other than the portions near the holes, so that ~~the~~ a radius will be smaller than at other portions and thus a pipe having a uniform radius will not result. Thus, work is ~~done~~ performed such that only ~~the portion~~ portions at the holes h will have the radius R0 of the finished product.

【0029】 In Figs. 2A(c) and 2A(f), which show ~~the~~ a rough forming step, ~~the~~ a reason why ~~the~~ a vertical position of the upper roll 1 is set at (Y2-θ) and Y2 is as follows. As shown in Fig. 4A, while bending the plate ~~work~~ W during rolling in ~~the~~ a going path, as described above, the straight portion, spiral portion and radius R' portion are formed with the upper roll 1 set at Y2-θ, so that the radius of the portions near the holes will be R0' which is smaller than at other portions. As shown in Fig. 4B, bending is ~~carried out~~performed with ~~the~~ a position of the upper roll 1 set at Y2 ~~in the~~during rolling in ~~the~~ a return path so that the radius at the hole portions will be the radius R0 of the finished product.

【0030】 ~~In the~~During rolling in the going and return paths, ~~the~~ contact points between the upper roll 1 and the lower rolls 2, 2' are T1, T2 and T3. ~~The way~~ A manner by which the plate ~~work~~ W contacts the upper and lower rolls 1, 2, 2' remains unchanged until the plate ~~work~~ W reaches the state of Fig. 4B. But when the plate ~~work~~ W further moves in the direction of the arrow beyond the state of

Fig. 4B, since the radius R0' at the hole portions h is different from the radius at the other portions, the ~~way~~ manner by which ~~they contact~~ the plate contacts the rolls at T2 and T1 changes, so that ~~slip~~ slippage occurs between the plate ~~work~~ W and the upper roll 1.

【0031】 In order to eliminate such ~~a slip~~ slippage, ~~the~~ a position of the upper roll 1 in the going path is set at Y2-θ, which is slightly above the position Y2 in the return path, so that ~~the~~ pressure exerted by the upper roll 1 will be greater in the return path than in the going path, thereby smoothly rolling while preventing ~~slip~~slippage. Thus, by setting the position of the upper roll 1 at Y2 for the rolling in the return path, the bending radius R0' of the portions at hole h in the going path will be ~~the~~ pipe radius R0 of the finished product, and ~~the~~ other portions will have a radius R which is slightly greater than R0.

【0032】 After the rough forming, as shown in Fig. 2B(h), the upper roll 1 is returned to the set position Y2-α and to ~~the~~ a central position between the lower rolls 2, 2'. At this position, no load is applied ~~on~~ to the plate ~~work~~ W. In order to return the plate ~~it~~ to this set position, the upper roll 1 is raised in step S34 to set position Y2-α, and the lower rolls 2, 2' are slightly driven in step S32 to feed them to set position γ so that the plate ~~work~~ W will be in a stable state on the lower rolls 2, 2'. And in step S36 in Fig. 3D, the upper roll 1 is returned to the central position.

【0033】 Next, in ~~the~~ a fine forming step shown in Fig. 2B(i) and subsequent figures, bending is ~~carried out~~performed so that the plate ~~work~~ will have the radius R0 as the pipe of the finished product. In step S38, the lower rolls 2, 2' are driven to return the plate ~~work~~ W to a predetermined position, and in step S40, the

upper roll 1 is lowered to set position Y4. At this time, steps S40, S41 and steps S38, S39 are parallelly ~~carried out~~performed. Thereafter in step S42, the lower rolls 2, 2' are driven to feed the plate ~~work~~ W to set position Z4 (Z4-1 + Z4-2 + Z4-3), and ~~the~~ bending in ~~the~~ a first fine forming step is ~~carried out~~performed. Thereafter, in the same manner, ~~the~~ lowering of the upper roll 1 and ~~the feed~~feeding of the plate ~~work~~ W by ~~means~~ virtue of the lower rolls 2, 2' are repeated three times to move the plate ~~work~~ to Y5 in step S44, to Z5 in step S46, to Y6 in step S48 and to Z6 in step S50.

【0034】 Details about feed to set positions Y4, Y5 and Y6 and set ~~position~~ positions Z4, Z5 and Z6 are shown in Fig. 2B(i) and the flowchart of Fig. 3E. In step S421, the lower rolls 2, 2' are driven to feed the plate ~~work~~ W to set position Z4-1. As shown in Fig. 2B(i), this position is a position just before the upper roll 1 reaches the holes h. At this set position, as shown in Fig. 2B(j), the upper roll 1 is raised in step S422 to set position Y4-β, the lower rolls 2, 2' are driven in step S423 to feed the plate ~~work~~ W to set position Z4-2. After passing the holes h, the upper roll 1 is lowered again to set it at position Y4. Thereafter, in step S425, the lower rolls 2, 2' are driven to feed the plate ~~work~~ W to Z4-3 to ~~carry out~~perform bending over ~~the~~ an entire circumference. After ~~carrying out~~performing the first fine forming in this manner, the plate ~~work~~ W is turned in ~~the~~ an opposite direction to ~~carry out the~~ perform a second fine forming with the upper roll 1 set at ~~the~~ position Y5. Next, the plate ~~work~~ W is reversed to ~~carry out the~~perform a third fine forming with the upper roll 1 set at position Y6.

【0035】 While an example in which the fine forming is ~~carried out~~performed three times has been described, ~~the~~ a number of fine formings may be more than or

less than three. In any fine forming, the upper roll 1 is raised a little not to ~~carry out~~perform bending near the holes h, and at any other ~~portions~~ portion the upper roll 1 is lowered little by little as the number of fine formings increases, to obtain the pipe radius R0 for the finished product. Also, ~~the~~ a set position for fine forming and ~~the~~ a number of risings and lowerings at the hole portions may be changed according to ~~the~~ a number of holes.

【0036】 As shown in Fig. 5, if the plate ~~work~~ W has holes hL and hS having different diameters, handling should be made so that the hole HL, which is larger in diameter, corresponds to the above-described hole h because ~~the~~ influence of the hole hS, which is smaller in diameter, is smaller than that of the larger-diameter hole hL.

【0037】 As described above in detail, in ~~the~~ a method and device for forming a pipe by bending a plate ~~work~~ having holes according to this invention, in ~~the~~ a rough forming step, ~~the~~ hole portions are formed to a required radius while ~~the~~ other portions are formed to a slightly larger radius. In ~~the~~ a fine forming step, pressing for bending is not ~~done~~ performed at the hole portions while the other portions are brought to a required radius by rolling little by little. Thus, simply by operating a bending machine, the plate ~~work~~ can be finished to a finished product without ~~the~~ need of correcting work using other auxiliary ~~means~~devices. Thus, a pipe can be formed accurately and efficiently by use of only a bending machine without troublesome work.

ABSTRACT OF THE DISCLOSURE

A method and a device are proposed which accurately and efficiently form a pipe with a bending machine only, without using any correcting ~~means~~devices. A plate ~~work~~ having holes is fed into a bending machine in which under an upper roll, lower rolls parallel thereto are arranged, and a pipe is formed ~~with~~ during a rough forming step and a fine forming step. In the rough forming step, bending is ~~done~~ performed so that ~~it~~ the plate will have a required diameter at ~~the~~ hole portions. In the fine forming step, the hole portions are not pressed for bending while ~~the~~ other portions are rolled so as to become closer to ~~the~~ a required diameter to form the pipe.